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A FALLOUT PLOTTING DEVICE

Research and Development Technical Report USNRDL-TR-127

NS 081-001
and
U. S. Army

30 November 1956

by

E.A. Schuert

DEPARTMENT OF THE NAVY · NAVAL RADIOLOGICAL DEFENSE LABORATORY

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

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Technical Objective
AW-7

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ABSTRACT

A fallout plotting device was developed. The method requires no drafting equipment and is ideally suited for field use. At Operation REDWING it was found that untrained personnel could quickly become proficient in its employment.

SUMMARY

The Problem

A plotting device is needed to speed up forecasting where fallout will fall in the field. Such a device should require no drafting equipment but still accurately plot the required data in a manner compatible with the latest fallout model theories. It should be so constructed that untrained personnel can quickly become proficient with it.

Findings

Such a device was developed and tested at Operation REDWING. It proved to be satisfactory, and suitable for field operations.

ADMINISTRATIVE INFORMATION

This work was done under Bureau of Ships Project No. NS 081-001, Subtask 1, Technical Objective AW-7. The work is described in U. S. Naval Radiological Defense Laboratory Annual Progress Report to the Bureau of Ships, DD Form 613, of July 1956 (Encl (1) to CO and Dir, USNRDL Secr ltr 3-905-471 EHC:dlc Ser 0014921 of 31 Aug 1956). The plotter was tested at Operation REDWING, Project 2.6.3, as described in Subtask 4B of NS 088-001 of February 1956.

The work also is part of the technical program for the Department of the Army established between Department of the Army, Office, Chief of Research and Development and Bureau of Ships (Joint Agreement, 23 November 1955).

INTRODUCTION

This paper describes a rapid technique for plotting "particle-size"* and "height" lines in mapping fallout from a nuclear detonation. Since this method, one of hand computation, uses a fallout plotting device that requires no drafting equipment, it is ideally suited for field use. It was employed successfully at Operation REDWING where it was found that untrained personnel could quickly become proficient in its employment.**

The use of particle-size and height lines in mapping fallout is a standard technique employed in most analytical methods now in use. It simply describes a grid (Fig.1) on the earth's surface indicating where certain sizes of fallout particles, originating along a line source through the axis of symmetry of the cloud, will arrive and from what altitude they will come. These parameters are the basic data for describing the fallout pattern.

There are three requirements for determining this grid: the initial distribution of material in the atmosphere; the falling or settling rate of the material from its initial elevation; and the wind field through which the material is falling and by which it is being displaced.

The fallout plotting device computes the points of arrival on the earth's surface of a given particle size that originates at various altitudes within the mushroom cloud and its stem. Particles originating at elevations of every 5000 ft, from the surface to 120,000 ft, are considered. In the construction of the device, account is taken of the variable speed of the settling particles due to changes in the vertical distribution of the atmosphere's density and viscosity. Aerodynamic falling equations were employed in its design. However, selection of particle falling speeds and altitude increments is arbitrary and not a fixed factor in the basic design of the plotter.

If the average wind speed and direction within a given altitude increment and the time required for a particle to fall through it are known, then the

* Particle-size lines are often referred to as hodographs or weighted hodographs.

** A USNRDL report which will describe the detailed techniques of forecasting used at Operation REDWING and how the employment of the plotter was adapted to consider time variation of the winds is in preparation.

horizontal displacement of the particle can be computed for that altitude layer. Knowledge of the particle's point of arrival on the surface may be deduced from tracing a settling particle as it is displaced by each wind in each altitude increment. Plotting trajectories for each particle size at every starting elevation is the first step in determining the resultant fallout pattern; however, the drafting involved is tedious and time consuming. This effort can be reduced greatly by plotting from the ground up, as is done in the construction of a hodograph. Such a plot is made by starting at ground zero and working up through the altitude increments to the desired elevation. Although this technique does not plot the trajectory of the particle, it does define the arrival points on the surface of the earth of particles starting at each altitude increment, (Fig.2).

DESCRIPTION AND USE OF DEVICE

To plot these size-lines one must make the preliminary computations of particle falling times through each altitude increment to obtain the displacement for various wind velocities. The plotter was designed with these computations built in, thereby speeding up the plotting process significantly.

The plotter consists of two parts, a base for direction or azimuth orientation and a wheel for distance or displacement. Since both of its parts are constructed of clear plastic, the plotter does not obscure the map over which it is placed. The base consists of a wind-rose having a radial line at each 10-degree interval on the compass. The base (Fig.3) has a narrow slot along the 180-degree line. If a given wind direction (in degrees from which the wind is blowing) is selected and its radial line oriented to north on the map (parallel to the north-south grids), the 180-degree slot becomes oriented in that direction in which a falling particle will be displaced. Thus by orienting the base of the plotter as described for any measured wind direction, the vector azimuth for the particle can be drawn through the slot of the plotter base.

The wheel (Fig.4) is pivoted at the center of the base. It has 24 equi-spaced radial slots. Each slot represents an altitude increment of 5000 ft. Concentric circles intersect the radial slots to form a scale of wind speeds in knots. Since the particle falling speed is a function of the atmosphere's density and viscosity and since these factors vary with altitude, the wind speed scales are so weighted that the indicated length of the scale actually represents the horizontal displacement of the particle through the altitude layer of interest.

To obtain the distance the particle is displaced along its azimuth, the wheel is rotated until the proper altitude layer is aligned with the 180-degree slot in the base and a line is plotted on the map.

It should be remembered that the weighted scales of wind speed fix the map scale, which in this case was 1:970,000 or 1 in. = 13.2 nautical miles. Different wind speed wheels have been constructed for several particle sizes; at present four wheels have been made.*

In plotting a size-line with the fallout plotter (Fig.5) one uses the same technique as one does when employing a drafting machine. However, all computations of horizontal displaced distance the particle experiences when falling through a given altitude layer are eliminated.

To plot a size-line or a trajectory, the following steps are necessary:

1. Rotate the wheel until the desired altitude increment coincides with the 180-degree slot in the base.

2. Place the plotter with the zero value of the wind speed scale over the given point and orient the base so that the radial line, showing the direction from which the wind blows, parallels the north-south grids of the map.

3. Draw a wind speed vector through the coincident slots.

4. Continue the process using the tip of the vector just drawn as the next point.

In constructing the prototype plotters certain specialized parameters were used in making the computations; for example, atmospheric density and viscosity were computed for a Marshall Island atmosphere, particle parameters were typical of coral fallout and special aerodynamic falling speed equations were used. Any of these variables as well as altitude increments may be so selected that a similar plotter for specialized or more general input data becomes possible. Also if one wished to assume a constant falling rate for a given size particle the wheel could be eliminated and the single wind speed scale laid out along the 180-degree slot on the base.

Figures 6A, 6B, 6C and 7A, 7B, 7C are reproductions of the component parts of the four plotters that have been constructed. These

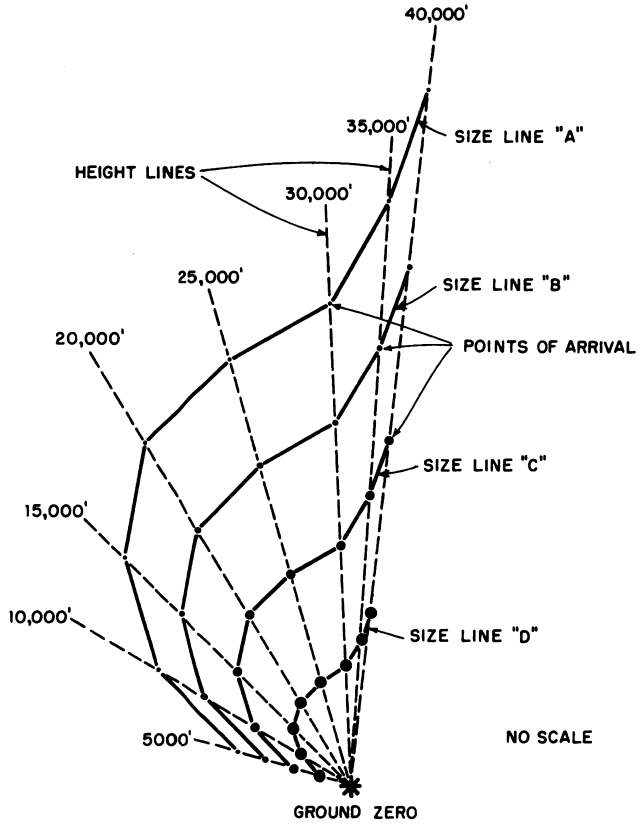
* These wheels are for irregular-shaped particles of density 2.36 g/cc and having diameters of 75, 100, 200 and 350 μ. A plotter may be adapted for more than one particle size by adding parallel scales to each radial slot on the wheel.

figures can be used to construct a set of plotting devices. A reference scale has been added on each figure to relate the reduced drawings to their original size wherein the scale relationship was 1:970,000.

Approved by:

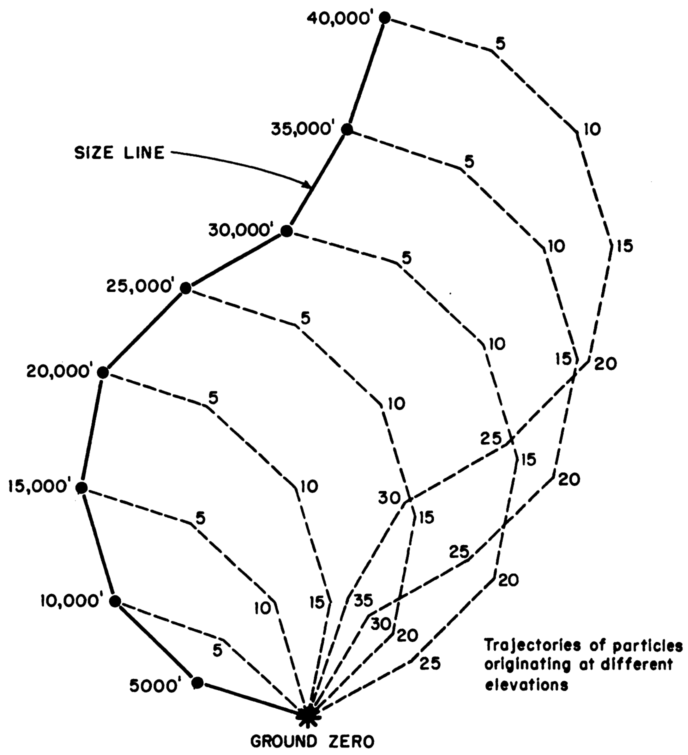
Eugene P. Cooper

EUGENE P. COOPER
Associate Scientific Director



NOTE: Four particle sizes originating at altitudes up to 40,000 feet in a hypothetical wind field

Fig. 1 Basic Fallout Plot Showing Grid of Size Lines and Height Lines



NOTE: Particles of the same size originating at altitudes up to 40,000 feet in a hypothetical wind field

NO SCALE

Fig. 2 Comparison of Plotting Techniques Either by Use of Trajectories or by Use of a Size Line

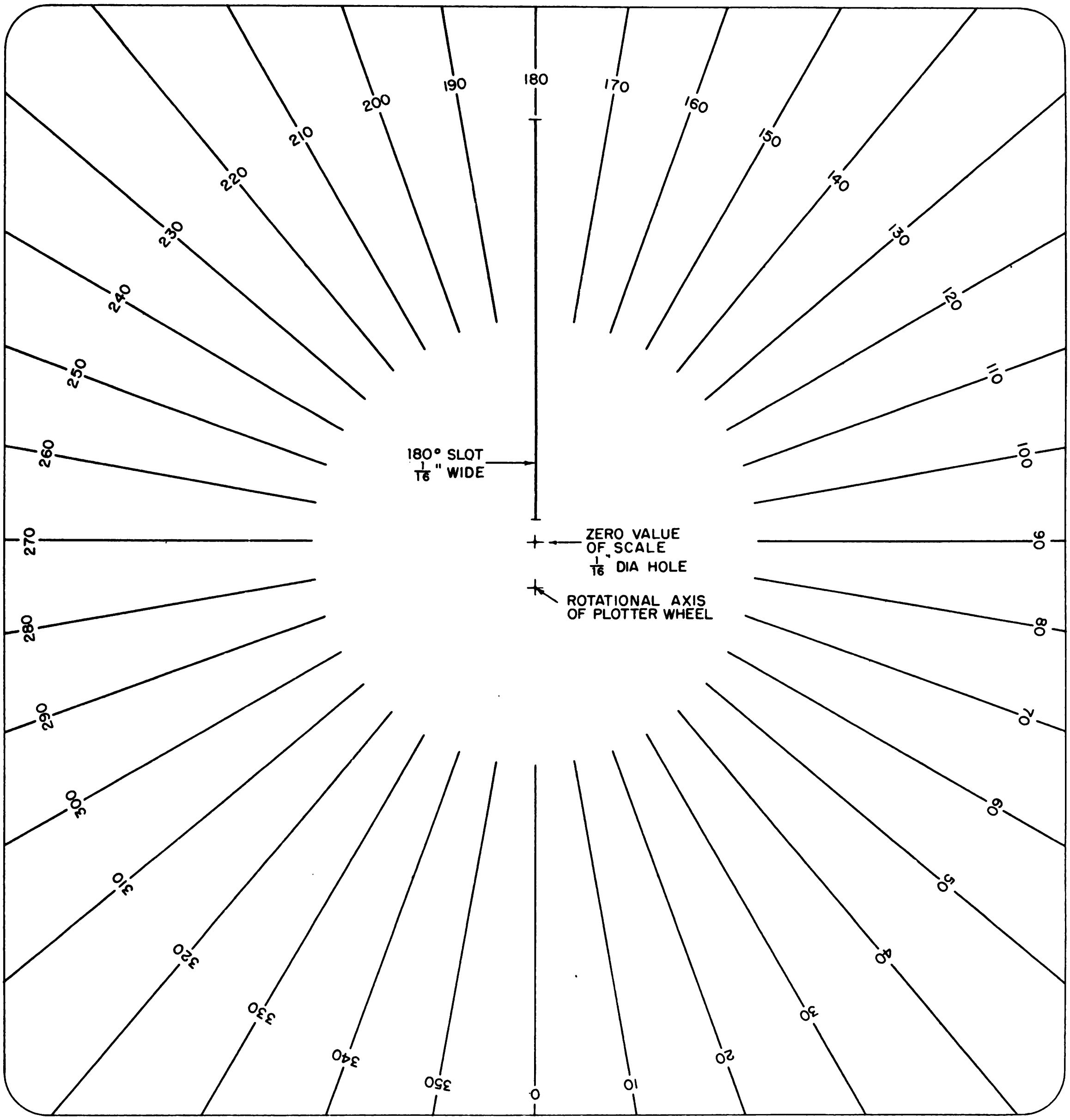


Fig. 3 Plotter Base, for Determining Direction

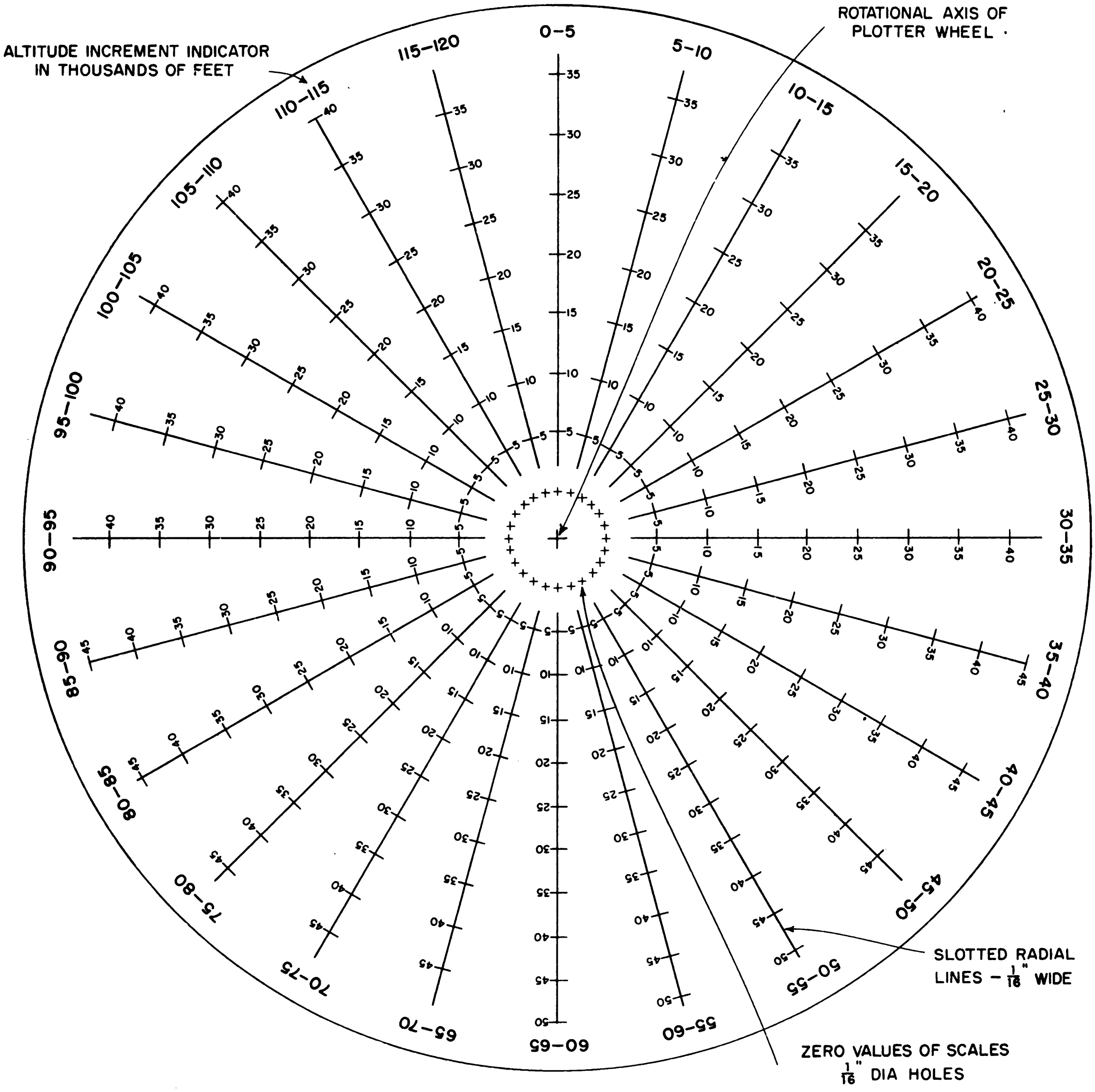


Fig. 4 Plotter Wheel for Determining Displacement of 75-μ Particles

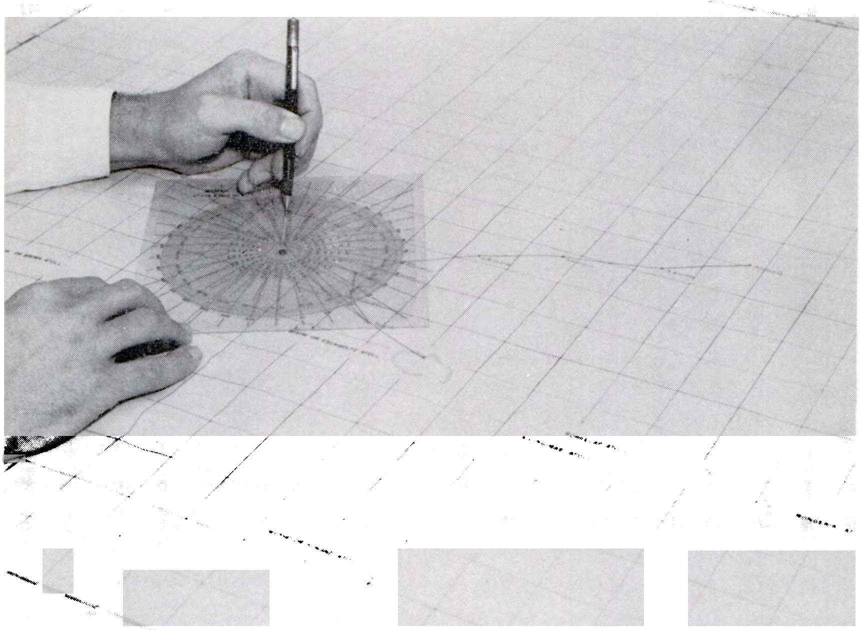


Fig. 5 Plotting Device Being Used.

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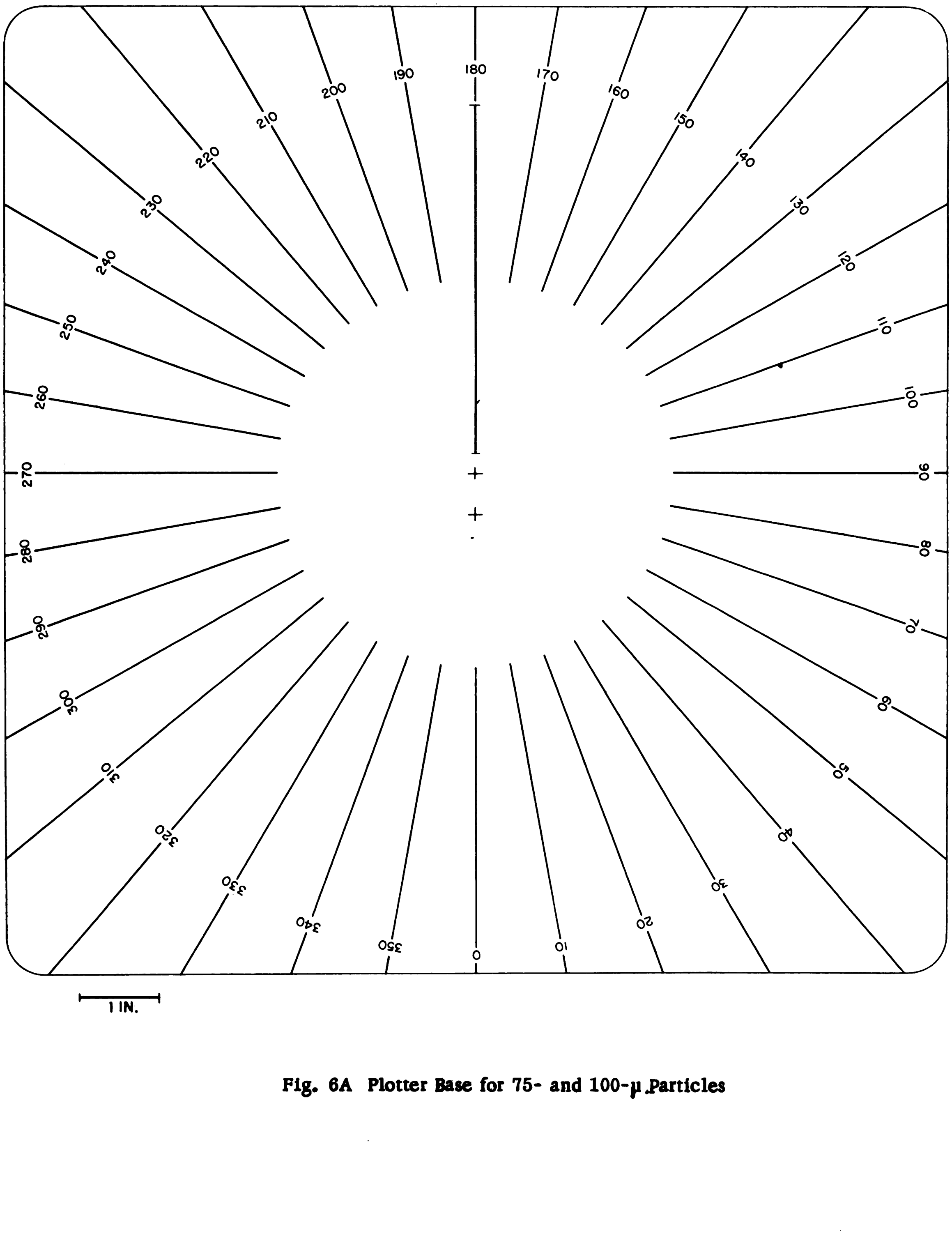

Fig. 6A Plotter Base for 75- and 100-μ Particles

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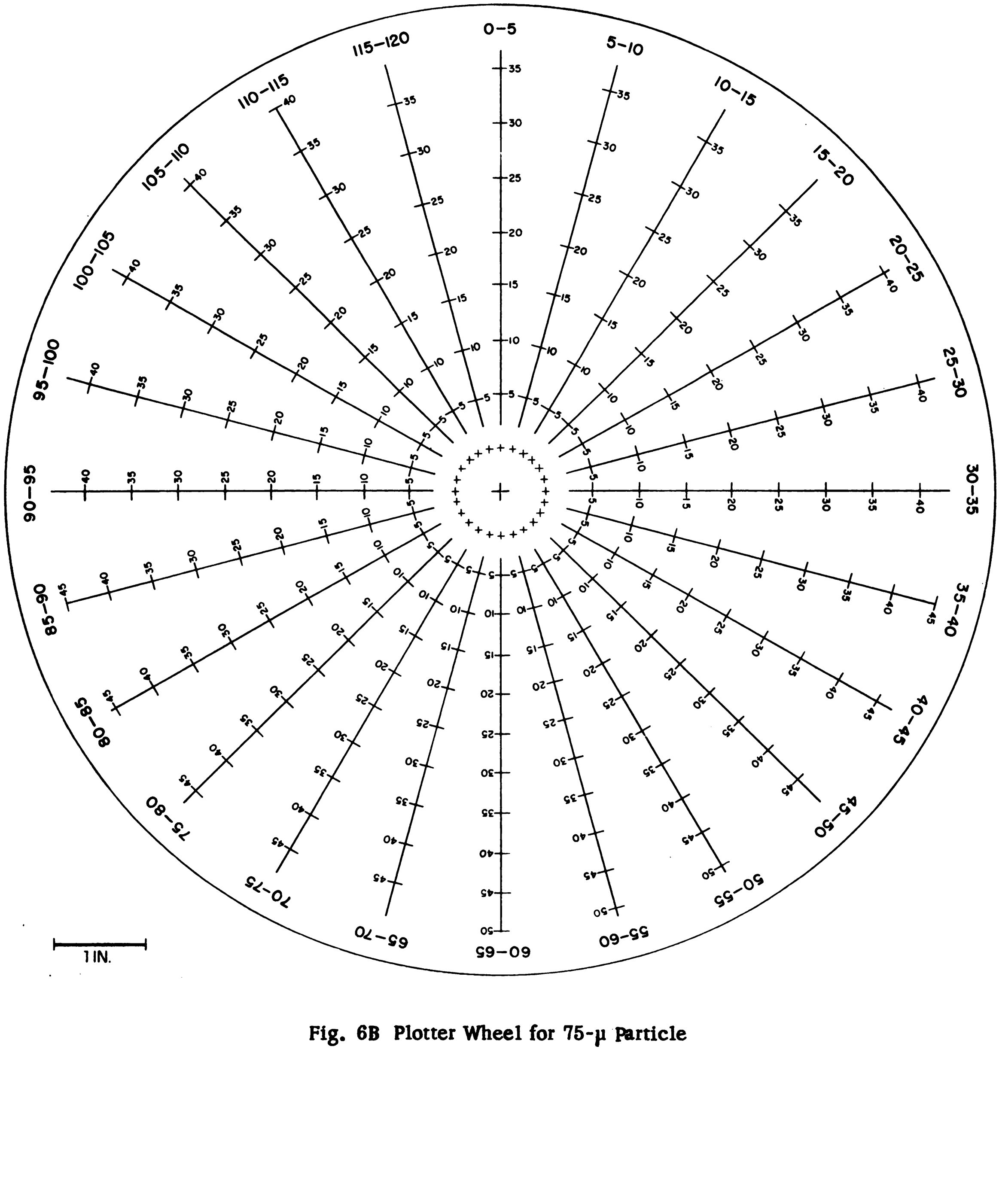

Fig. 6B Plotter Wheel for 75-μ Particle

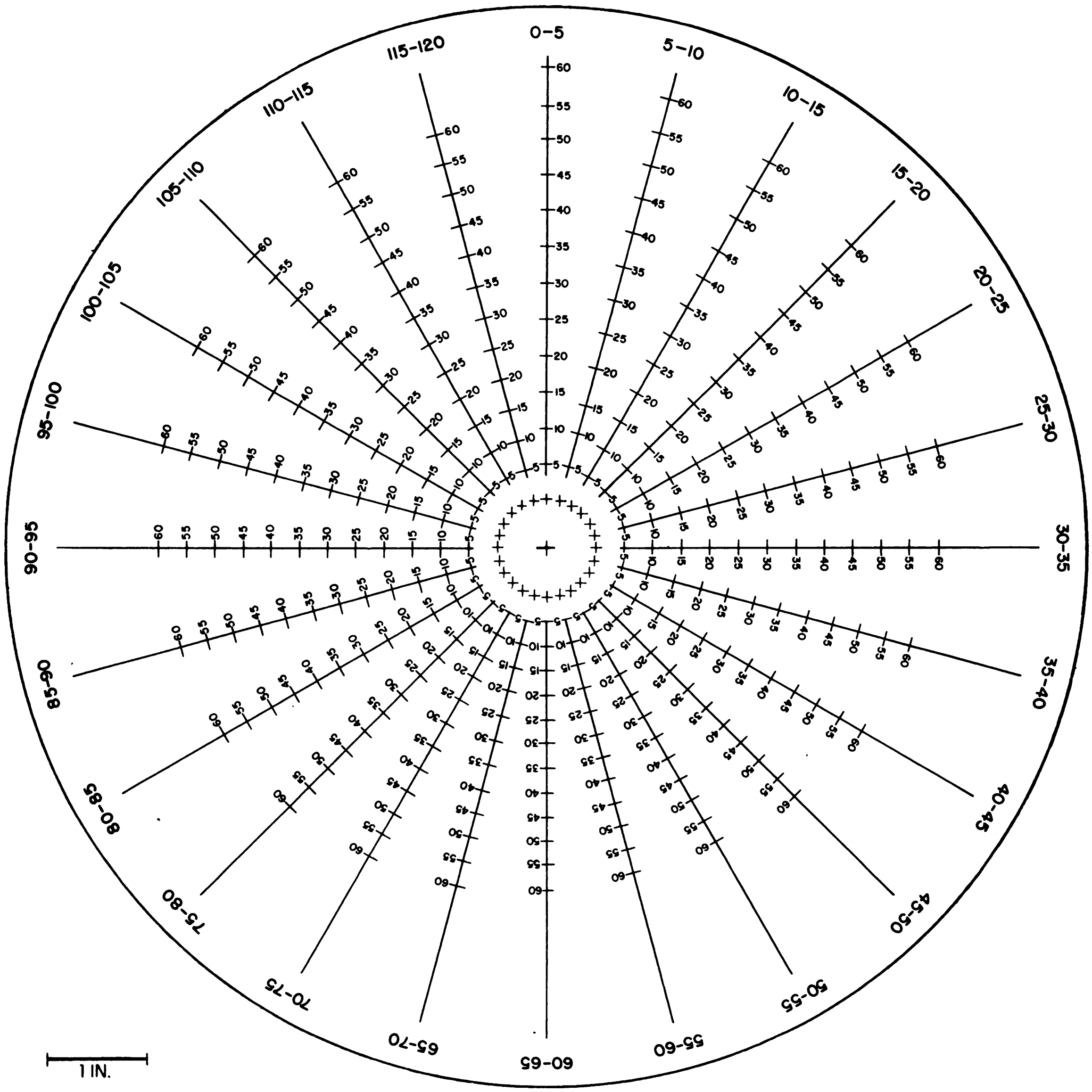

Fig. 6C Plotter Wheel for 100-μ Particle

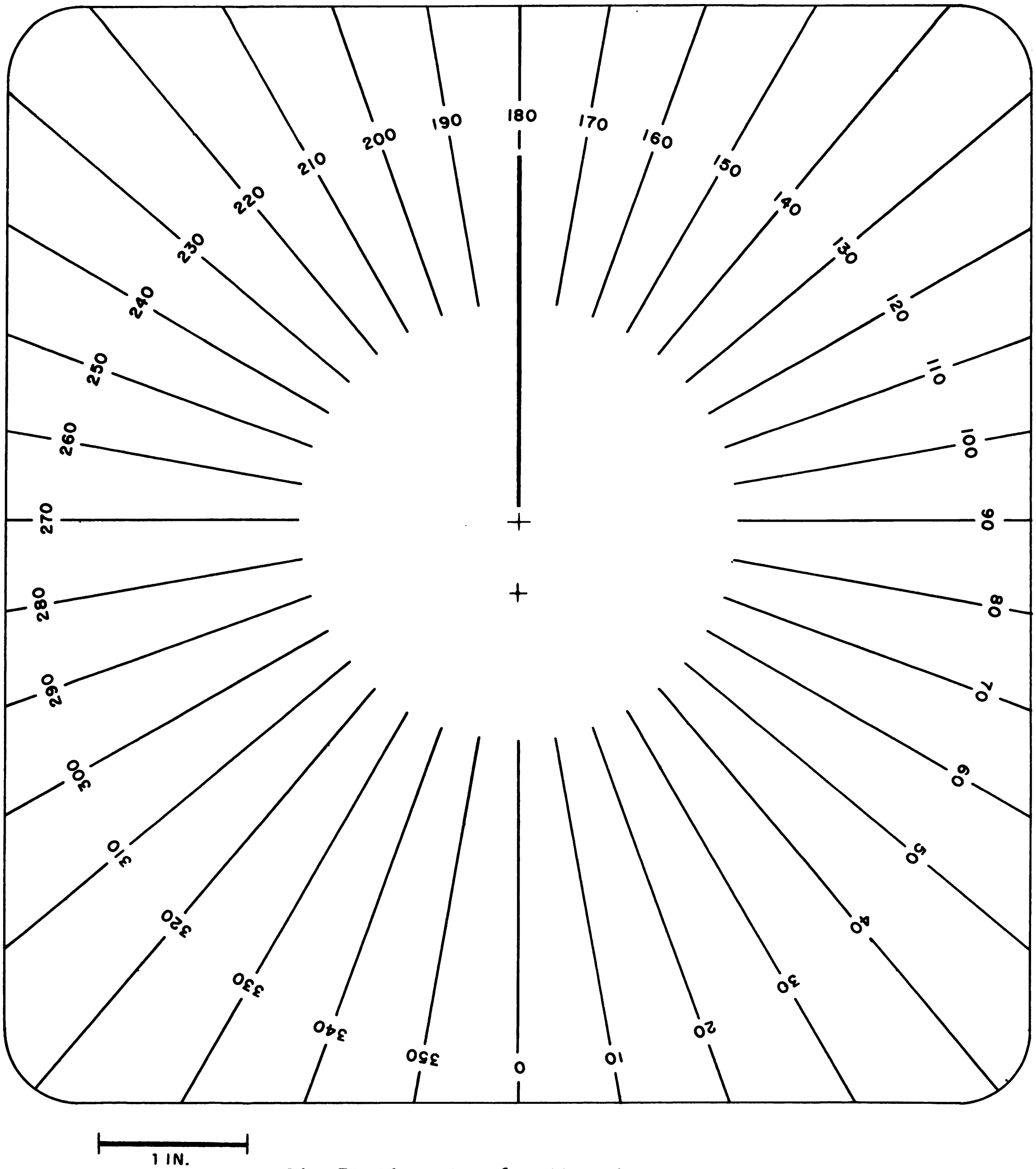

Fig. 7A Plotter Base for 200- and 350-μ Particles

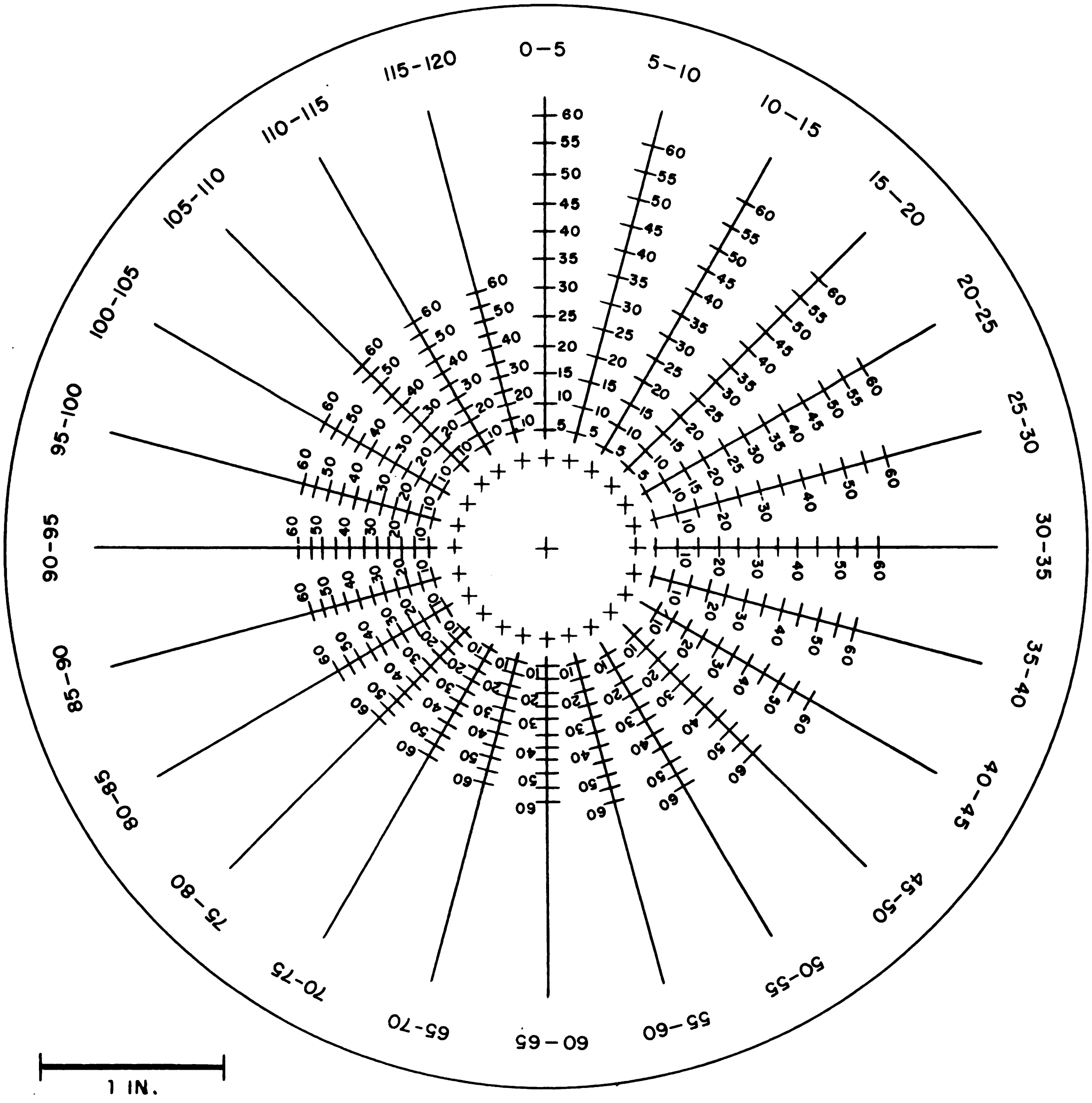

Fig. 7B Plotter Wheel for 200-μ Particle

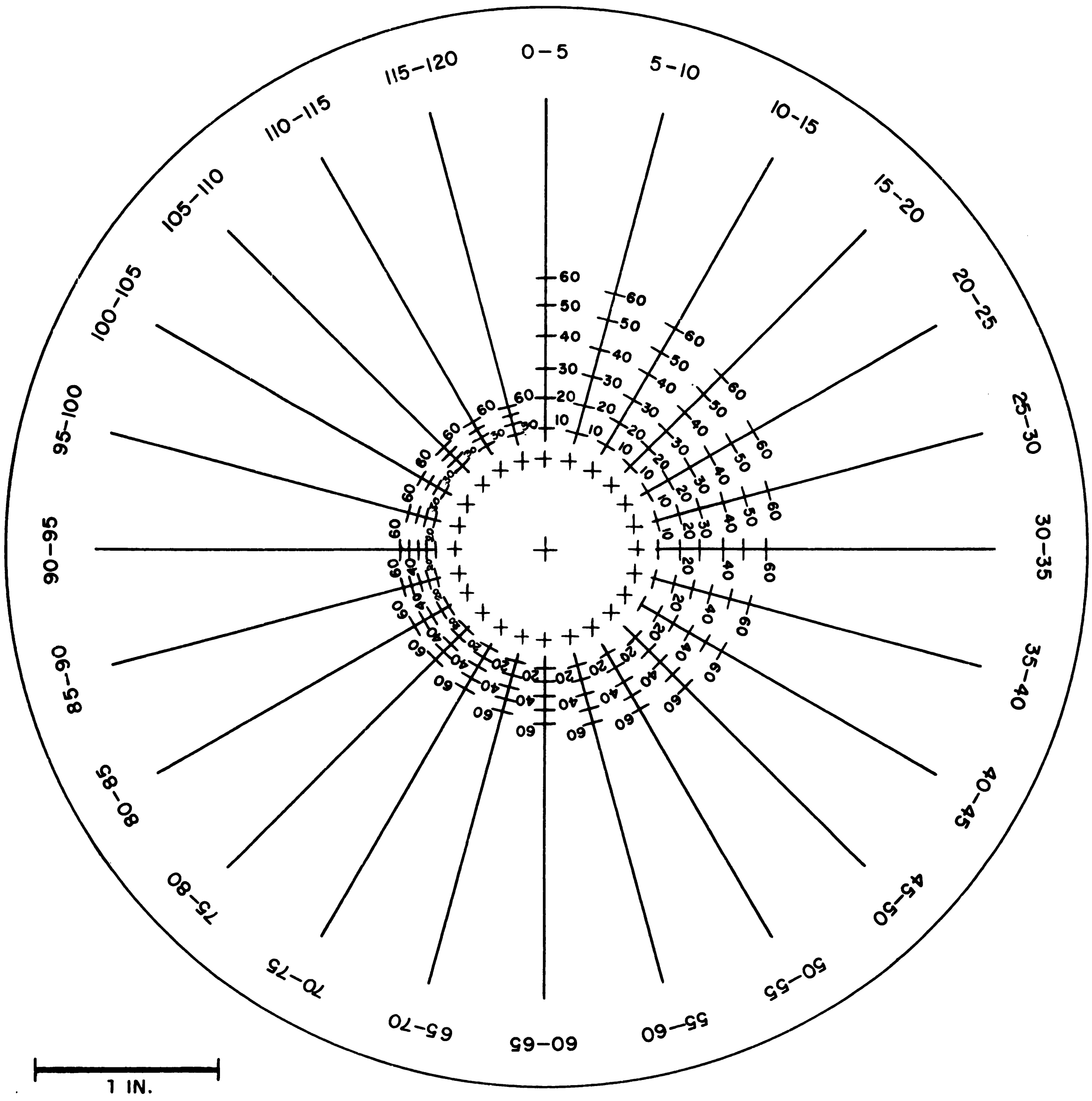

Fig. 7C Plotter Wheel for 350-μ Particle

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2. Plotters
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